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Circumumbilical incision for neonatal abdominal surgery: additional skin incision when there is difficulty in manipulating the intestine

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ABSTRACT

This study aimed to evaluate the safety and effectiveness of circumumbilical incision (CUI) for neonates requiring intestinal anastomosis. Seventy neonates requiring intestinal anastomosis at our institution between 2003 and 2020 were included in this retrospective case-control study. Patients were classified into the CUI (25 patients: 36%) and transverse incision (TI) groups (45 patients: 64%). Postoperative complications and surgical outcomes were compared between the two groups. Intestinal perforation at the non-anastomotic site occurred significantly more often in the CUI group than in the TI group (3 patients: 12%, and 0 patients: 0%, respectively (p = 0.042)). There were no between-group differences regarding anastomotic leakages, anastomotic strictures, time to enteral feeding, operative time, and blood loss. Neonatal intestinal surgery employing CUI might be associated with increased intestinal perforation at the non-anastomotic site. Hesitating to enlarge the skin incision to maintain favorable cosmetic outcomes might cause severe injury to the delicate neonatal intestine during the surgical procedure owing to the restricted surgical field. When performing CUI, we suggest that the skin incision should be extended without hesitation whenever there is difficulty in manipulating the intestine.

Keywords: circumumbilical incision, neonates, intestinal atresia, meconium peritonitis

Abbreviations:
CUI: circumumbilical incision
FEEA: functional end-to-end anastomosis
TI: transverse incision

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INTRODUCTION

Cosmetic outcome following abdominal surgery is one of the most important factors in determining the choice of operative procedures. Since the introduction of circumumbilical incision (CUI) for pediatric surgery by Tan and Bianchi,[1] CUI has been applied in various neonatal surgeries.[2] Several studies have reported that, in neonatal surgery, CUI provides superior cosmetic outcomes compared to transverse incision (TI) with equivalent surgical outcomes.[3] We have routinely utilized CUI for neonatal intestinal surgeries. When we encountered difficulty in manipulating the dilated intestine or in order to adequately determine the intra-abdominal condition, we performed an extended midline and/or omega-shaped skin incision. However, CUI with an extended incision would often result in an inferior cosmetic appearance. Therefore, there is often hesitation in performing CUI with an extended incision in order to retain more favorable cosmesis. In this study, we evaluated the safety and effectiveness of surgery using our CUI procedure in neonates requiring intestinal anastomosis.

MATERIALS AND METHODS

We conducted a retrospective case-control study at our institution. We retrospectively reviewed the clinical records of neonatal patients who underwent intestinal anastomosis between January 2003 and December 2020. Patients were classified into the CUI and TI groups. The patients' characteristics and surgical outcomes were compared between the groups. Data collected included gestational age and weight at birth, age and weight at surgery, sex, preoperative white blood cell count, diagnosis, procedure, incision, operative time, blood loss, time to initial/full enteral feeding, and early postoperative complications.

The primary outcome was postoperative complications, including anastomotic site leakage and stricture, and intestinal perforation at a non-anastomotic site. The secondary outcome was surgical outcomes in both groups. Complications were classified using the Clavien-Dindo classification[4] and complications classified as grade IIIa or worse were evaluated. Complications that developed within 90 days after surgery were included.

Operative technique

Surgery was performed either using CUI or TI. At our institution, from 2013, CUI was selected as the first-line procedure due to its superior cosmetic outcomes. The CUI was created at the superior aspect of the umbilicus whereas the TI was made in the upper abdomen. The round ligament of the liver and the linea alba were divided, and a wound retractor was inserted into the abdominal cavity. If difficulty was encountered in searching the main lesion or exteriorizing the intestine, the skin incision was extended.

Reconstruction either involved functional end-to-end anastomosis (FEEA) or hand-sewn anastomosis. In FEEA, a linear stapler is inserted in the proximal and distal intestinal limbs after dissecting the lesion. A side-to-side anastomosis was then created at the anti-mesenteric side. Their common opening was closed either with a stapler or using a hand-sewn technique. Hand-sewn anastomosis was performed using single-layer end-to-end anastomosis in an interrupted fashion using a 5-0 or 6-0 monofilament suture. The application of FEEA was based on the surgeons' preference.

Statistical analysis

Continuous variables are expressed as medians (interquartile range). The Mann-Whitney U-

test was used to compare continuous variables. The Fisher's exact probability test was used to analyze the difference between discrete variables. A p-value < 0.05 was considered statistically significant. All statistical analyses were performed using R software 3.5.0.[5]

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of Nagoya Graduate School of Medicine (No. 2020-0605) and performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consent was obtained from the patients' legal guardians.

RESULTS

A total of 70 neonates requiring intestinal anastomosis were included in this study. The CUI group included 25 (36%) patients and TI group included 45 patients (64%) (Table 1). There were five cases requiring additional skin extension in the CUI group (one case: midline extension, four cases: omega-shaped extension).

Patients' background

Gestational age and weight at birth, age and weight at surgery, and sex were not significantly different between the groups. Preoperative white blood cell was significantly higher in the CUI group ($15.3 \times 10^3/\mu L$ [$(13.9 – 17.6) \times 10^3/\mu L$] vs $12.1 \times 10^3/\mu L$ [$(9.2 – 7.0) \times 10^3/\mu L$], $p = 0.020$).

Table 1 Patients' details

	CUI (n = 25)	TI (n = 45)	p value
Baseline characteristics			
Gestational age at birth[a]	36w2d (34w5d–37w5d)	36w3d (35w1d–38w4d)	0.583
Weight at birth, kg[a]	2.6 (2.2–3.1)	2.6 (2.2–2.9)	0.565
Age at surgery, day[a]	1 (0–1)	1 (0–3)	0.583
Weight at surgery, kg[a]	2.6 (2.2–3.0)	2.7 (2.2–2.9)	0.704
Male, n (%)	9 (36%)	26 (58%)	0.134
Pre-operative WBC, $\times 10^3/\mu L$[a]	15.3 (13.9–17.6)	12.1 (9.2–17.0)	0.020*
Diagnosis			
Intestinal atresia, n (%)	25 (100%)	33 (73%)	0.003*
Type of intestinal atresia (I/II/IIIa/IIIb/IV)	12/2/7/1/3	9/9/8/4/3	
Meconium peritonitis, n (%)	0 (0%)	12 (27%)	0.003*
Operation characteristics, n (%)			
FEEA	21 (84%)	5 (11%)	< 0.001*
The common opening closed by hand-sewn	4 (16%)	Not applicable	
Small bowel resection with anastomosis	25 (100%)	43 (96%)	0.534
Membranectomy with anastomosis	0 (0%)	2 (4%)	0.534
Tapering	2 (8%)	8 (18%)	0.314

[a] Median (interquartile range)

* Significant difference

FEEA: functional end-to-end anastomosis

Regarding intestinal atresia, the CUI group included types I (n = 12), II (n = 2), IIIa (n = 8), IIIb (n = 1), and IV (n = 3). The TI group included types I (n = 9), II (n = 9), IIIa (n = 8), IIIb (n = 4), and IV (n = 3). There were no cases of meconium peritonitis in the CUI group, but there were 12 cases in the TI group.

Operative characteristics

Of the 25 cases in the CUI group, five (20%) required additional skin incision during the surgical procedure. Four of the five cases had omega-shaped extensions and one had a midline skin extension. FEEA was significantly higher in the CUI group than in the TI group (21 patients: 84% vs 5 patients: 11%, $p < 0.001$). The common opening was closed by hand-sewing in four (16%) cases and stapler in 17 (84%) cases. In the CUI group, small bowel resection was performed in all 25 cases (100%). In the TI group, small bowel resection was performed in 43 cases (96%) and two cases (4%) involved membranectomy. Forty-five cases were anastomosed using hand-sewn anastomosis. The rate of tapering of the proximal dilated bowel was not significantly different between the CUI and TI groups (2 patients: 8% vs 8 patients: 18%; $p = 0.314$).

Postoperative complication analysis

Regarding postoperative complications (Table 2), anastomotic site leakage and stricture were not significantly different between the CUI and TI groups (leakage: 0 (0%) vs 1 (2%); $p = 1$ and stricture: 3 (12%) vs 3 (7%); $p = 0.659$). The intestinal perforation at a non-anastomotic site was observed in the CUI group, and none in the TI group, showing a significant difference (3 (12%) vs 0 (0%), $p = 0.042$). Surgical site infection was not significantly different between the CUI and TI groups (2 (8%) vs 0 (0%); $p = 0.124$).

Table 2 Surgical outcomes

	CUI (n = 25)	TI (n = 45)	*p* value
Postoperative complications, n (%)	6 (23%)	4 (9%)	0.151
Anastomotic site leakage	0 (0%)	1 (2%)	1
Anastomotic site stricture	3 (12%)	3 (7%)	0.659
Intestinal perforation at non- anastomotic site	3 (12%)	0 (0%)	0.042*
Operation time, min[a]	100 (81–117)	96 (72–120)	0.375
Blood loss, mL[a]	11 (4–28)	5 (1–25)	0.270
Time to initial enteral feeding, day[a]	5 (4–9)	5 (4–7)	0.286
Time to full enteral feeding, day[a]	18 (12–23)	15 (12–21)	0.467
SSI, n (%)	2 (8%)	0 (0%)	0.124
Superficial incisional SSI	1 (4%)	0 (0%)	0.357
Deep incisional SSI	1 (4%)	0 (0%)	0.357
Hospitalized day	43 (31–66)	45 (27–82)	0.832

[a] Median (interquartile range)

* Significant difference

SSI: surgical site infection

Complications occurred in 10 cases and are detailed in Table 3. Anastomotic site leakage occurred in one case as a result of stapler site leakage in the TI group. Regarding stricture, excessive kinking at the anastomosis site occurred in 2 cases in each group, intestinal ischemia

occurred in one case in the CUI group, and anastomotic stricture occurred in one case in the TI group. No cases of perforation occurred within 10 cm of the anastomotic site. All cases of perforation occurred before enteral feeding and in patients in the CUI group in whom no incisional extension was performed. Intraoperative findings in cases with postoperative complications showed non-specific characteristics other than mild adhesion.

Table 3 Analysis of postoperative complications

	Age	Wt	Dx	Reoperation	SI	Reconstruction	Lesion site
Leakage	0 (d)	2216	MP	POD 7	TI	FEEA	–
Stricture	1 (d)	2260	IA (IV)	POD 44	CUI	Hand-sewn	–
	1 (d)	2860	IA (I)	POD 11	CUI	FEEA	–
	1 (d)	3350	IA (IIIa)	POD 38	CUI	FEEA	–
	0 (d)	2463	MP	POD 21	TI	Hand-sewn	–
	1 (d)	1488	IA (IV)	POD 28	TI	FEEA	–
	1 (d)	2178	IA (IV)	POD 8	TI	Hand-sewn	–
Perforation	0 (d)	2204	IA (I)	POD 4	CUI	Hand-sewn	25 cm proximal from ICV
	1 (d)	2720	IA (I)	POD 4	CUI	Hand-sewn	10 cm proximal from anastomosis site
	3 (d)	2628	IA (I)	POD 12	CUI	FEEA	5 cm distal from Treitz ligament, unspecified jejunum, and 10 cm proximal from ICV

CUI: circumumbilical incision
d: day/old
Dx: diagnosis
FEEA: functional end-to-end anastomosis
IA: intestinal atresia
ICV: ileocecal valve
MP: meconium peritonitis
POD: postoperative day
SI: skin incision
TI: transverse incision
Wt: weight (g)

Surgical outcomes

Table 2 shows the surgical outcomes in both groups. There were no significant differences between the two groups in operative time [CUI vs TI groups: 100 min (81–117 min) vs 96 min (72–120 min), $p = 0.375$], blood loss [11 mL (4–28 mL) vs 5 mL (1–25 mL), $p = 0.270$], time to initial enteral feeding [5 days (4–9 days)] vs 5 days (4–7 days), $p = 0.286$], time to full enteral feeding [18 days (12–23 days) vs 15 days (12–21 days), $p = 0.467$], and hospitalized days [43 days (31–66 days) vs 45 days (27–82 days), $p = 0.832$].

DISCUSSION

CUI has been used for various pediatric surgeries and its excellent cosmetic and surgical outcomes have been recognized. However, its relatively small incision sometimes results in difficulty in the exteriorization of large-sized structures, such as pyloric tumors and dilated intestines.[6] Some studies reported that a modified CUI, including omega-shaped or midline extensions, could be useful to exteriorize larger pyloric structures.[2,6] Although the surgical procedure and delivery of the intestine become easier, the modified CUI with its additional extension can produce an inferior cosmetic appearance.

Our study revealed that overall postoperative complications and other surgical outcomes were not significantly different between the two groups; however, intestinal perforation at the non-anastomotic sites occurred significantly more frequently in the CUI group.

Although the cause of perforation was multifactorial, we speculated that CUI was one of causes associated with the fragility of neonatal intestine. FEEA was performed significantly more frequently in the CUI group. To our knowledge, there is little evidence that FEEA contributes to the non-anastomotic site perforation. Our previous reports and surgical findings suggested that FEEA itself did not cause non-anastomotic site perforation. Thus far, we have reported that FEEA was able to anastomose intestines with size discrepancies within a shorter surgical time[7] and with equivalent surgical outcomes as hand-sewn anastomosis.[8] Considering that two of the three cases were hand-sewn, FEEA was not associated with that complication. To safely anastomose the intestine through an umbilical incision, the proximal and distal intestines around the lesion were fully exteriorized. When difficulty in exteriorization of the intestine was encountered, our procedures might have resulted in an unreasonable mechanical force on the intestine. This mechanical force could severely damage the intestine, and result in perforation and bleeding of the intestine at a non-anastomotic site. The small incision created in CUI was related to the difficulty in checking the intra-abdominal condition and resulted in exposure to additional mechanical force during the exteriorization of the intestine, which might have contributed to the high perforation rate observed in our study.

When we selected CUI for neonatal surgery, we aimed to obtain favorable surgical and cosmetic outcomes. We often managed to perform the operation without extension of the CUI because additional skin incisions result in a poor cosmetic appearance. However, when difficulty was encountered in performing the surgical procedure or confirming the intra-abdominal condition, and the extended incision was required, midline and/or omega-shaped extension were performed. The extension of the incision can result in less force on the intestine, thereby leaving the intestine undamaged. In fact, no cases of perforation occurred in patients in the CUI group with additional extension. We evaluated the effect of an additional skin incision to the surgical field. We basically performed CUI by incising at the contact line between the umbilical cord and skin, and extended the midline skin incision by approximately 0.5 cm and the omega-shaped skin incision by approximately 0.5 cm. The diameter of umbilical cord was reported to be approximately 1.0 cm.[9] Assuming the abovementioned data (CUI was assumed to be two-thirds of the circular incision), we calculated the surgical field to evaluate the effects of skin extension. As comparative data, we used the surgical field of TI with 3.0-cm incision because the minimal incision length in the TI group was 3.0 cm. The surgical field was calculated by the circumference of the wound, supposing the wound was pseudo-circle, by using a wound retractor. The calculated circumference lengths were 2.96 cm of the CUI, 3.96 cm of the CUI with midline extension, 4.96 cm of the CUI with omega-shaped extension, and 6 cm of the TI. As a result, each surgical field was 0.70 cm^2 of the CUI, 1.25 cm^2 of the CUI with midline extension, 1.96 cm^2 of the CUI with omega-shaped extension, and 2.86 cm^2 of the TI. In clinical setting, the surgical field is considered larger than

these calculations because the neonatal skin is flexible and can be easily elongated. However, the surgical field of the CUI is relatively small; thus, we suggest you do not persist to make a small wound incision, but rather extend the skin incision to safely perform the operation.

Our study had limitations. First, it was single-center retrospective case-control study. Our results should be validated in a study involving a large population and conducted at different locations. Second, the sample size was small; therefore, the statistical power was low; thus, a significant difference may not have been observed in some results. Third, there was a selection bias in our study because both surgical approaches of the CUI and TI were used since 2013. The TI approach was possibly selected in cases wherein CUI is difficult to perform.

CONCLUSIONS

CUI is a cosmetically superior approach to the TI in neonatal surgery with generally equivalent surgical outcomes. In this study, neonatal intestinal surgery using CUI was associated with intestinal perforation at the non-anastomotic sites. Our hesitation to enlarge the skin incision to maintain favorable cosmetic outcomes might result in severe injury to the delicate neonatal intestine during the surgical procedure in the restricted surgical field. Therefore, when performing CUI, we suggest that the skin incision should be extended without hesitation in cases where there is difficulty in manipulating the intestine.

CONFLICTS OF INTEREST

The authors declare that they have no competing interest.

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